Space Network (SN) Overview and Potential Range Safety Application

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Agenda

- Space Network (SN)/TDRSS Overview
- Potential Use of TDRSS for Range Safety

Space Network / TDRSS Overview

- Space Network Concept
- Operational TDRS Coverage
- Space Network Configuration
- GSFC Networks Division Responsibilities
- Networks Division Organization Structure
- TDRSS Services
- Current Constellation/Availability
- Service Summary/System Capacity
- Space Network Ground Segment
- Support Services
- Proficiency

Space Network Concept

- The Space Network (SN) was established to replace NASA's worldwide network of ground tracking stations
- The SN dramatically increased Tracking and Data Acquisition (T&DA) coverage from 15% to 85% per orbit of low earth orbiting spacecraft as well as decreased operational costs
- Addition of the GRO Remote Terminal System (GRTS) in Australia further increased T&DA coverage to 100% by providing data acquisition contingency support to Compton Gamma Ray Observatory.
- Future augmentation to the SN with a Space-to-Ground Link Terminal (SGLT) at Guam will close the Zone of Exclusion (ZOE).
- The SN operates as a customer driven bent pipe relay system for tracking, telemetry, and command data

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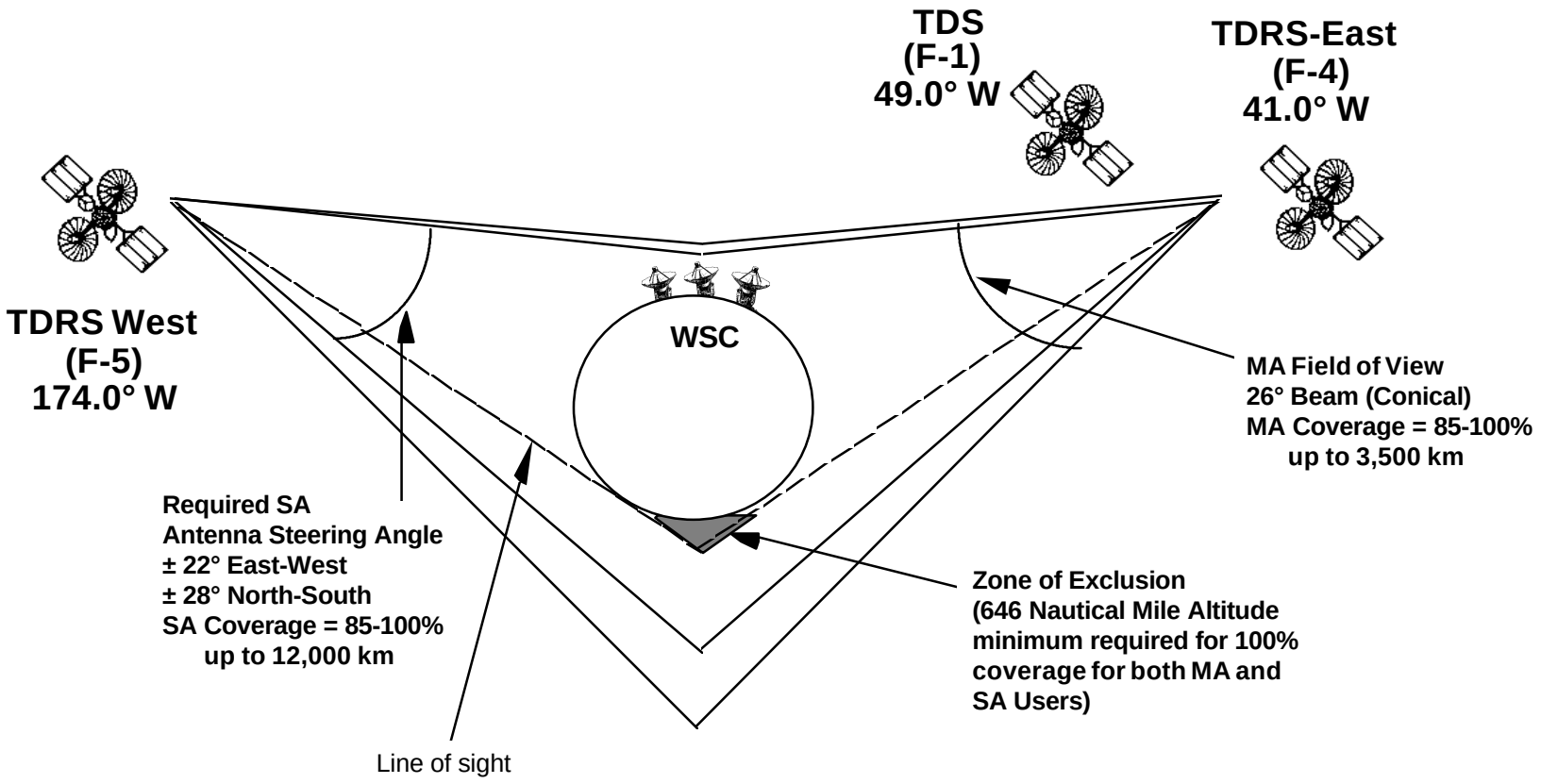
Operational TDRS Coverage



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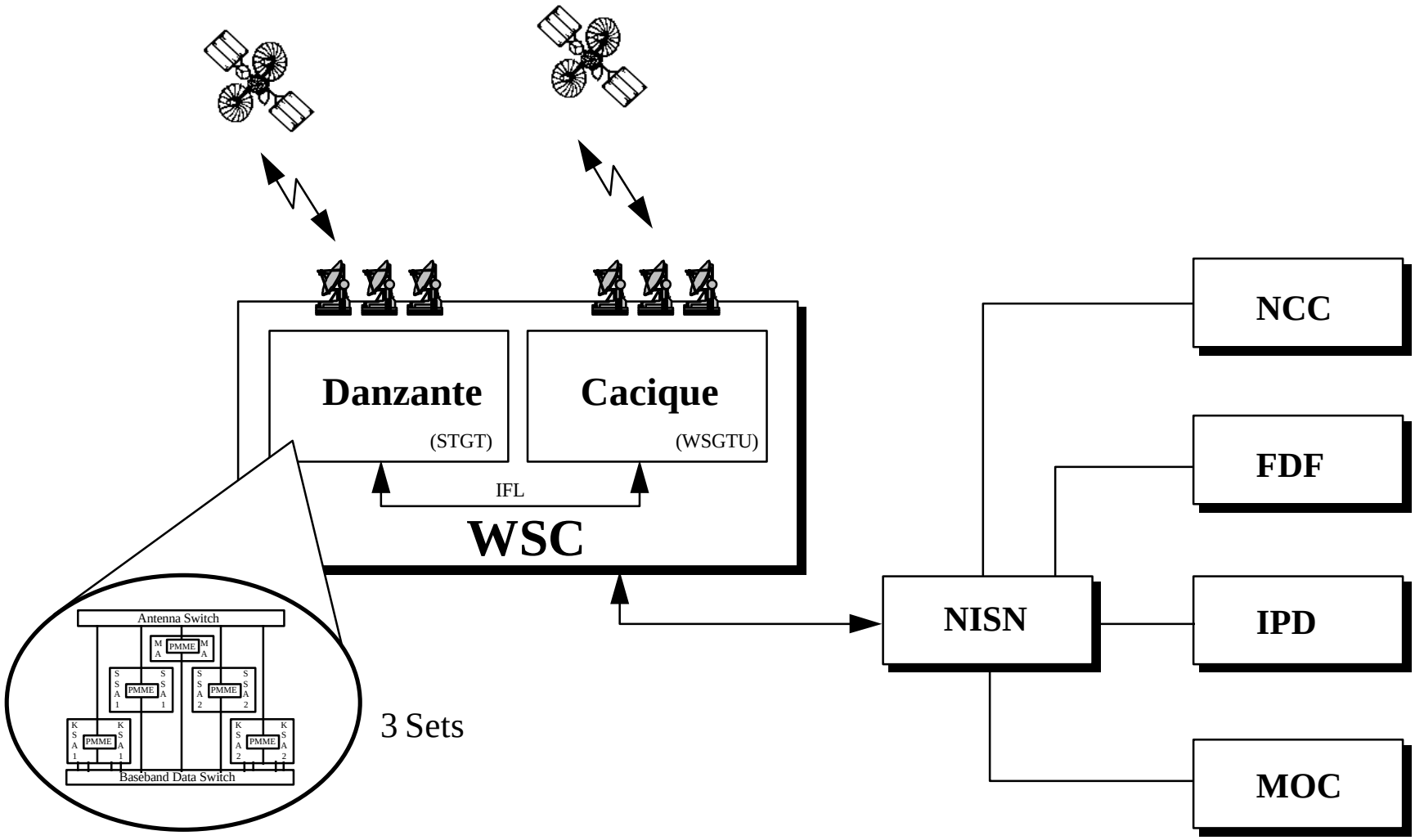
SN Configuration



GSFC Networks Division Responsibilities

The Networks Division is responsible for program planning, direction, and operation of NASA's SN:

- Management of the tracking/data communications facilities and systems, providing day-to-day support of launch and orbital activities
- Improvements and upgrades of present networks systems to improve current user service capabilities
- Establishment of long range technology initiatives to meet future user service requirements
- Provision of networks institutional support

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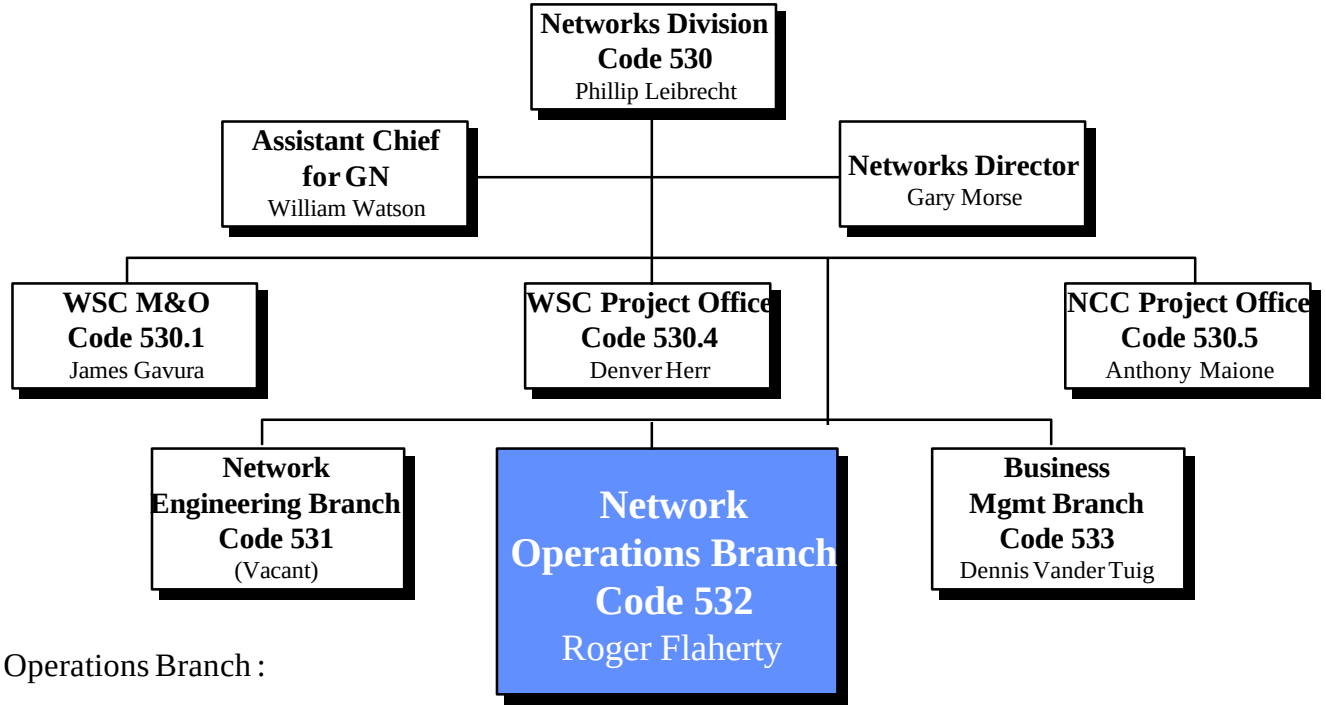
Networks Division Organization Structure



The Networks Operations Branch :

- Manages
  - All Networks Division operations activities
  - The engineering and operations of Network facilities
  - Network security, including physical, operational, and communications security
  - The technical operations and engineering documentation system
  - Comprehensive test programs for mission readiness, engineering, and system acceptance
- Maintenance and operations of the Space and Ground Networks
- Schedules and directs real-time network support
- Integrates multiple support networks in response to customer requirements
- Develops and defines network commitments and operational plans to support network customers
- Develops operations concepts, plans, and requirements for future network capabilities and customer activities
- Controls network configurations to support various customer activities

TDRSS Services

- **Mission Planning**
  - **Requirements definition, engineering, and integration**
- **Testing**
  - **Characterization, and verification/validation testing for evaluating mission readiness**
- **Operations Planning**
  - **Develop and coordinate the implementation of approved network enhancements to support new and evolving requirements**
  - **Ensure SN elements are prepared to support approved mission requirements. Implement necessary database connectivities**
- **Pre Launch Support**
  - **Payload & launch vehicle RF checkout**
- **Launch Support**
  - **Tracking and data acquisition via TDRSS**

TDRSS Services (cont'd)

- **Command**
  - **POCC commands transmitted directly via NISN (Nascom) to WSC**
  - **WSC uplinks commands to TDRS for RF transmission to customer S/C**
- **Telemetry**
  - **Customer data received via TDRS at WSC**
  - **WSC down converts, demodulates, bit synchronizes, records data, and sends asynchronous data to Nascom equipment for transmission to customers**
- **Tracking**
  - **One-way doppler and frequency determination**
  - **Two-way range using DG-1 PN code and Doppler**
- **Control/Status**
  - **Link control messages (GCMRs) and performance monitoring data**

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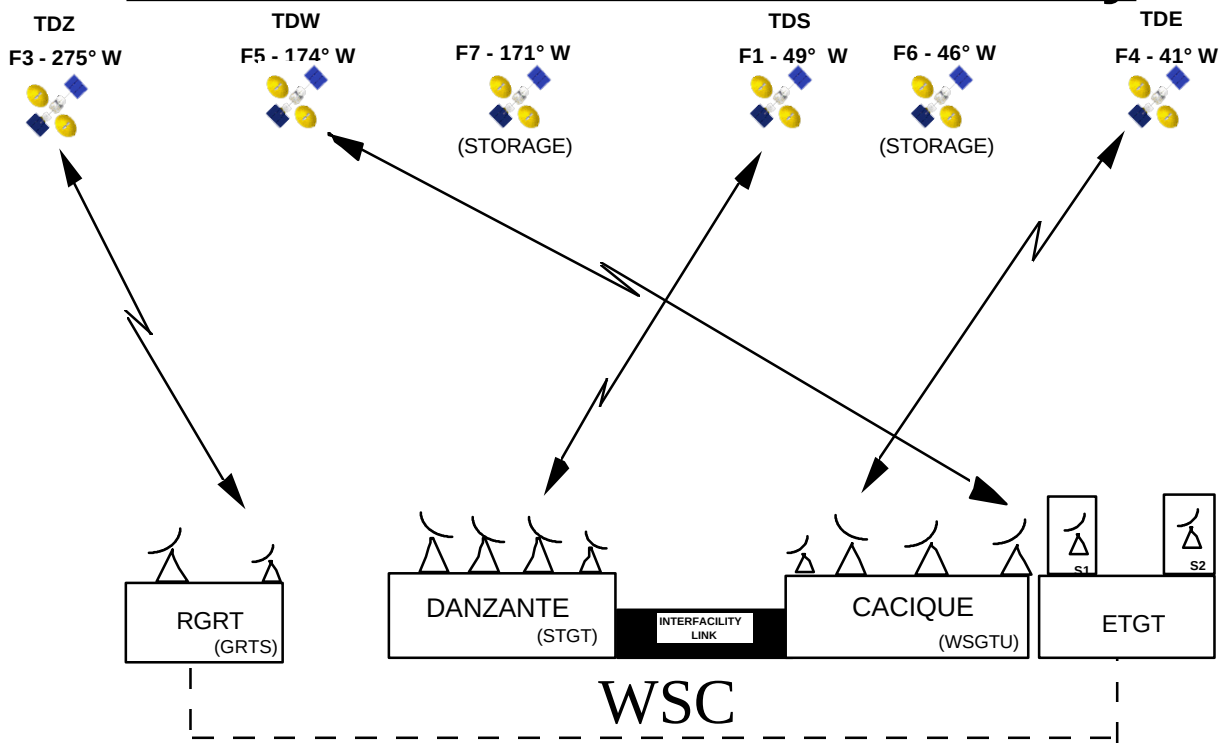
Current Constellation/Availability



TDRS	Availability
F-1	Reduced Capability
F-3	Reduced Capability
F-4	Full capability through 1998. Reduced Capability in 2003* (Projected)
F-5	Full capability through 2000. Reduced Capability in 2003 (Projected)
F-6	Full capability. Stored
F-7	Full capability. Stored
TDRS-H	Launch Scheduled July 1999
TDRS-I	Launch Scheduled January 2000
TDRS-J	Launch Scheduled July 2000

* If C-Band recommendations are accepted for deleting C-Band services.

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Current Constellation/Availability (cont'd)

	Launched	Geosynchronous Orbit	In-Orbit Checkout	Utilization
TDRS-1	April 4, 1983 STS-6 (Challenger)	June 29, 1983	- December 28, 1983 - One Satellite System Acceptance April 1985	- Currently At 49°W - Designated TDRS -S pare - Used Prime for ELV Launches
TDRS-3	September 29, 1988 STS-26 (Discovery)	September 30, 1988	- January 15 1989 - Two Satellite System Acceptance July 1989	- Currently Designated As TDRS-ZOE At 275°W
TDRS-4	March 13, 1989 STS-29 (Discovery)	March 14, 1989	June 9, 1989	- Currently Designated As TDRS East At 41°W & Providing Full Support
TDRS-5	August 2, 1991 STS-43 (Atlantis)	August 3, 1991	October 7, 1989	- Currently Designated As TDRS West At 174°W & - Providing Full Support
TDRS-6	January 13, 1993 STS-54 (Endeavor)	January 14, 1993	March 4, 1993	- Currently At 46°W - Stored Spare
TDRS-7	July 13, 1995 STS-70 (Discovery)	July 14, 1995	August 22, 1995	- Currently At 171°W - stored spare

TDRS-2 LOST JANUARY 28, 1986 ABOARD STS-51L (CHALLENGER)

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Service Summary/System Capacity

		FREQUENCY	SERVICE	MAX. DATA RATE
SINGLE ACCESS	S BAND	2020.4 MHz - 2123.3 MHz	FORWARD	300 kbps
		2200 MHz - 2300 MHz	RETURN	6 Mbps
	K BAND	13.747 GHz - 13.802 GHz	FORWARD	25 Mbps
		14.887 GHz - 15.119 GHz	RETURN	300 Mbps
MULTIPLE ACCESS	S BAND	2103.1 MHz - 2109.7 MHz	FORWARD	10 kbps
		2284.5 MHz - 2290.5 MHz	RETURN	100 kbps

* Fully operational S/C

NOTE:
TDRS H, I, J support Ka-Band and Higher Gain MA

Space-to-Ground Link Antenna

2.0 Meter Parabolic Reflector
Dual Orthogonal Linear Polarization for TDRSS
- Single Horn Feed
- Orthomode Transducer
Two Axis Gimballed

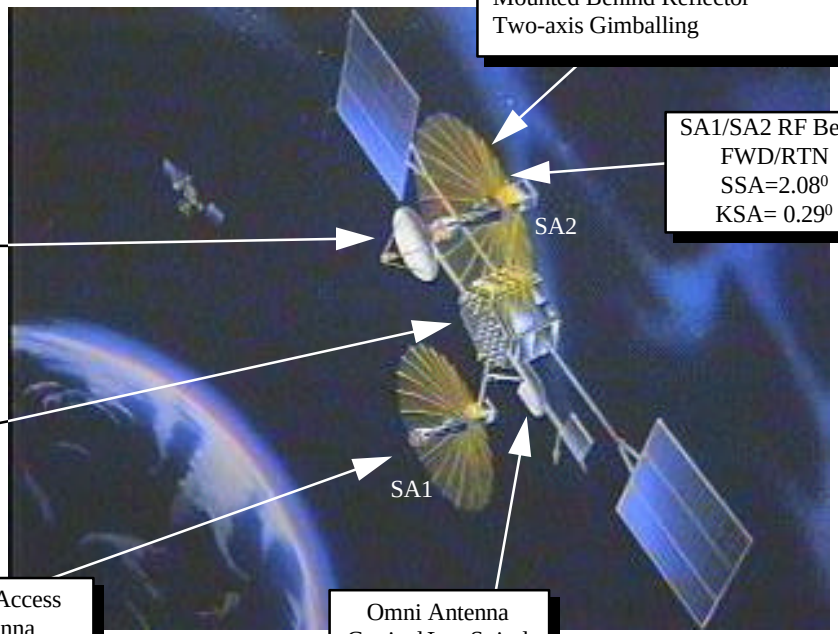
Multiple Access Antenna

30 Helices
- 12 Diplexed for Transmit
- 30 Receive
Body Mounted
Single Commanded Beam on Transmit
20 Adapted Beams Receive
Ground Implemented Receive Function

Single Access Antenna

Mesh 4.9 Meter deployable Shaped
Reflector Assembly
Dual Frequency Communications and Tracking Functions
- S-Band TDRSS (SSA)
- K-Band TDRSS(KSA)
- K-Band Autotracking
SA Equipment Compartment Mounted Behind Reflector
Two-axis Gimballing

SA1/SA2 RF Beam
FWD/RTN
SSA=2.08^0
KSA= 0.29^0



Single Access Antenna

Omni Antenna
Conical Log Spiral

Space Network Ground Segment
(Major Elements)

- Network Control Center (NCC)
  - Operational hub located at Goddard Space Flight Center for coordinating all Space Network activities
- White Sands Complex (WSC)
  - Two independent, functionally identical TDRS ground stations for controlling the TDRS
  - ETGT for TDZ mission support
- Remote Ground Relay Terminal (RGRT)
  - Located in Canberra, Australia to provide extended coverage for the GRO spacecraft

Support Services

- NISN (Wide Area Networks)
  - Provides point to point voice and data communication services
  - Fully Redundant Paths
- Flight Dynamics Facility
  - Provides TDRS and customer acquisition data including:
    - » TDRS & Customer antenna pointing data
    - » Customer attitude and orbit determination
- Information Processing Division
  - Processes select telemetry data for S/C principal investigators
  - Provides common experiment interface to flight instrument sponsor for data distribution

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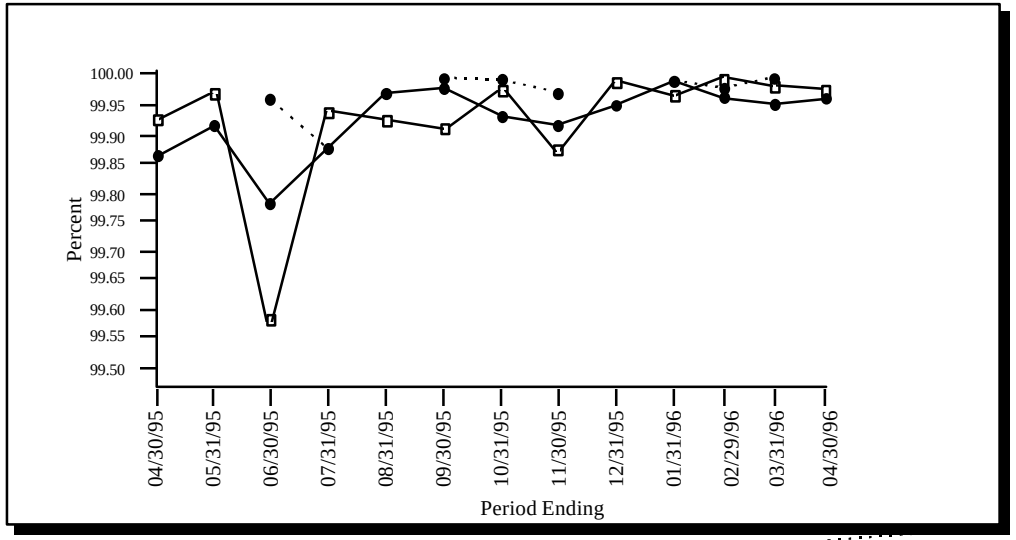
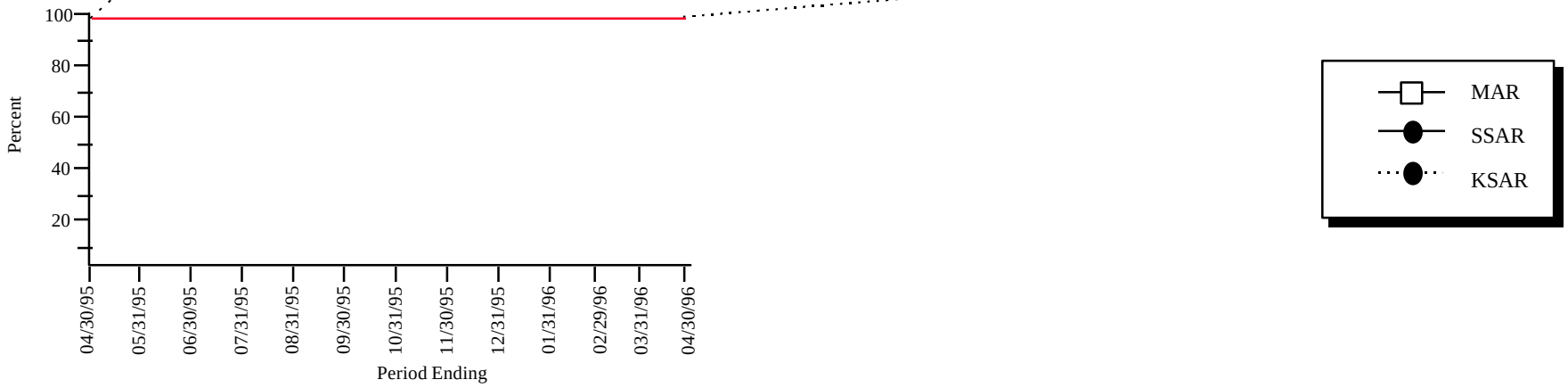
Proficiency

(Scheduled vs. Actual Return Minutes)





Potential Use of TDRSS for Range Safety

- Introduction
- Concept of TDRSS Range Safety
- TDRSS Conceptual Coverage Diagram
- SN Time Delay
- TDRSS Conceptual Support Capabilities
- Advantages of SN Support Services
- Operational Issues
- Status of TDRSS Range Safety Activities
- Conclusion/Summary

Introduction

Today's changing technical and fiscal environment requires NASA to assess and reengineer its customer support capabilities and processes:

- Cost of the current systems/methods
- Doing more with less
- Closing of NASA Ground Stations
- NASA and DOD Budget Constraints
- Technological Advancements
- Maintaining Safety

Concept of TDRSS Range Safety

- Continuous coverage of All Launch Phases
- Tracking and Data Acquisition
- Additional and/or Contingency Coverage
- S-Band Commanding (Potentially)

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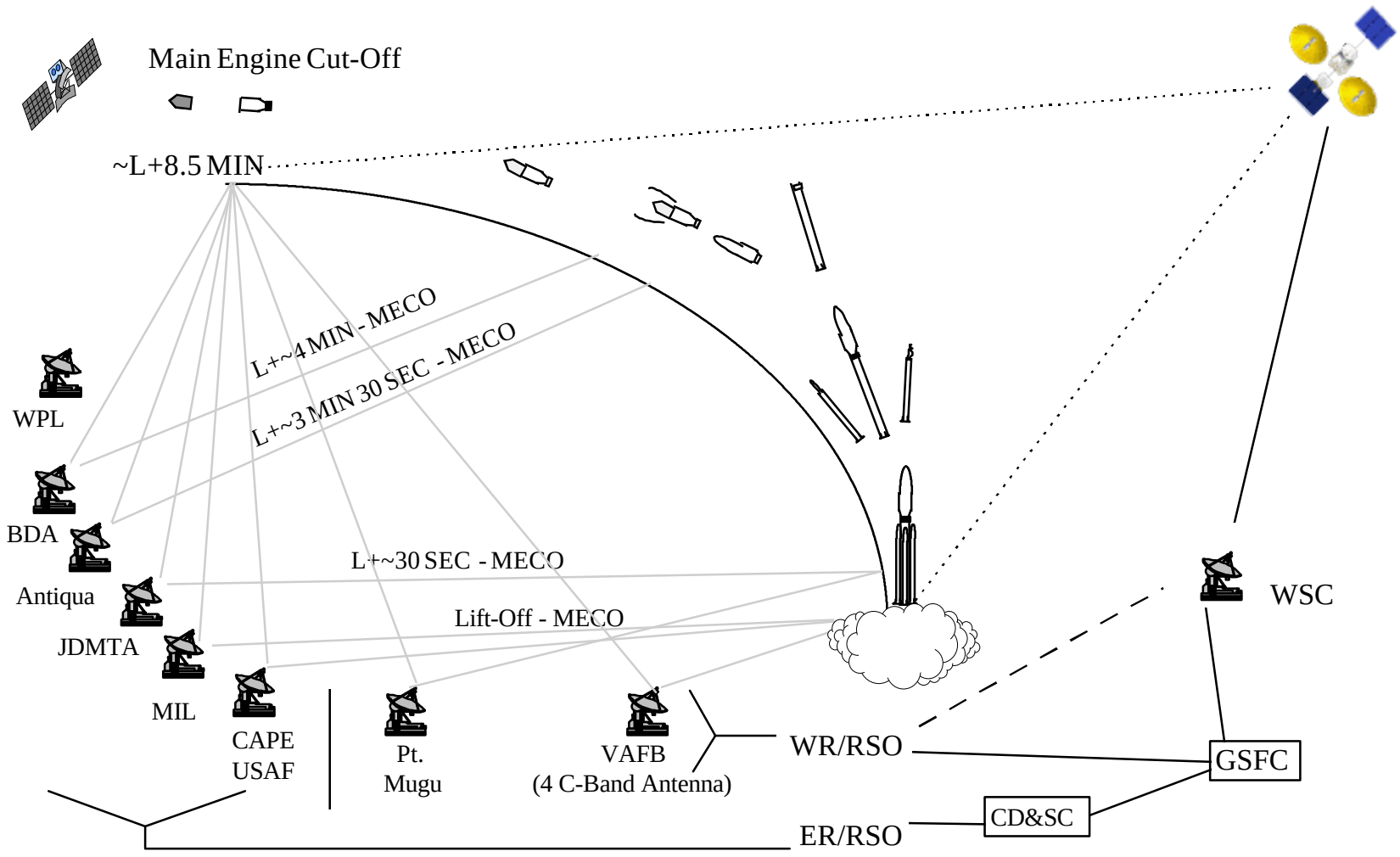
TDRSS Conceptual Coverage Diagram



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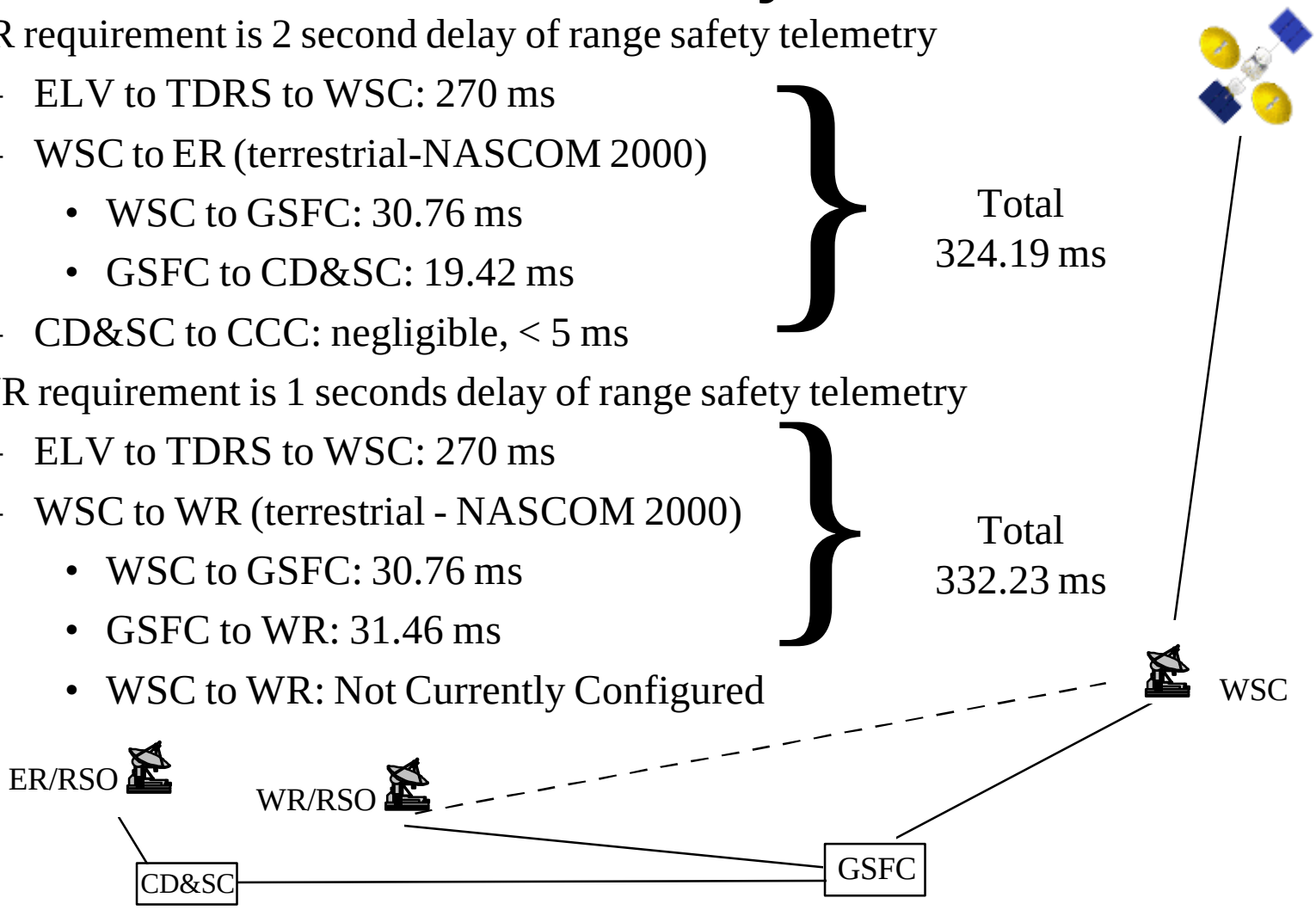
SN Time Delay

- ER requirement is 2 second delay of range safety telemetry
  - ELV to TDRS to WSC: 270 ms
  - WSC to ER (terrestrial-NASCOM 2000)
    - WSC to GSFC: 30.76 ms
    - GSFC to CD&SC: 19.42 ms
  - CD&SC to CCC: negligible, < 5 ms

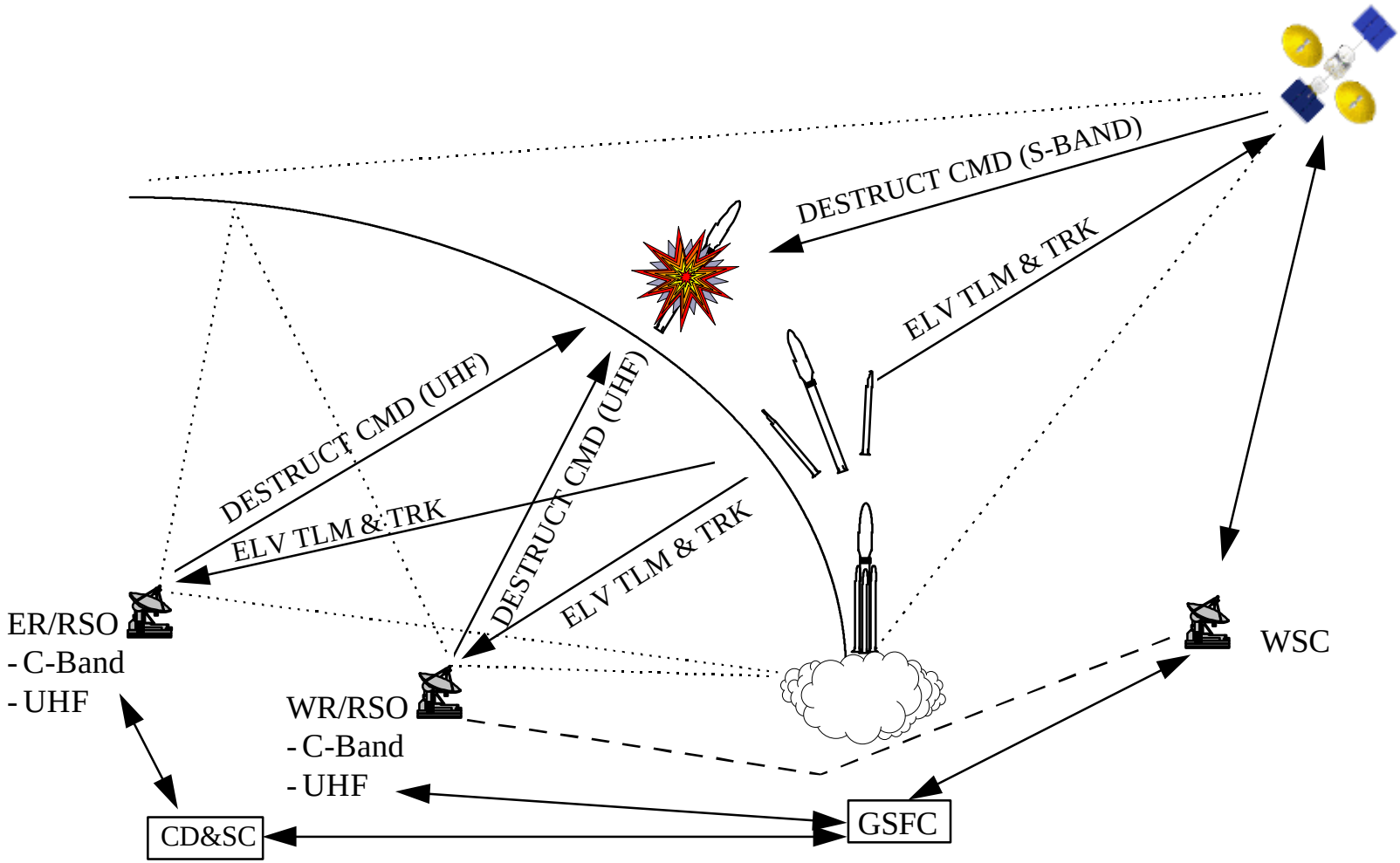
Total 324.19 ms

- WR requirement is 1 seconds delay of range safety telemetry
  - ELV to TDRS to WSC: 270 ms
  - WSC to WR (terrestrial - NASCOM 2000)
    - WSC to GSFC: 30.76 ms
    - GSFC to WR: 31.46 ms
    - WSC to WR: Not Currently Configured

Total 332.23 ms



TDRSS Conceptual Support Capabilities



Advantages of SN Support Services

- Space-borne Platform
  - Ready Asset,
  - High Coverage Area
- Quick Drop Lock Reacq Time
- Redundant Paths (Ground)
- Low Maintenance & Operations Cost

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Operational Issues

CHALLENGES	RESPONSE
• Latency	• SN/TDRSS latency data provided. Bent pipe mode, OK. Data processing needs evaluation
• ELV Systems would require modifications	• Industry (Cincinnati Electronics) is working on a system that could provide secure range safety via TDRSS. Anticipated Performance Characteristics: – Acceptable Signal Acquisition Time – Positive Link Margins - Using Current Vehicle S-Band Antenna – Immunity to Jamming Capability – Secure Command PN Sequence Selection
• TDRS Availability (Loading Study to be performed)	• Currently ELV launches gets top priority. (Additional TDRS resources could be made available.)
• Demodulation of TDRS downlink stream for range safety parameters	• Uncertain where this would take place and the latency impact (depends on customer request)
• The Role of TDRSS	• Until proven to be a reliable resource, run in shadow/backup mode

Status of TDRSS Range Safety Activities

- Accomplishments
  - 2nd TDRSS Workshop/Range Safety Splinter Group
  - NASA HQ Meeting invited (by Networks, Inc.) to discuss TDRSS Range Safety activities
  - Requirements Analysis
    - » RCC 319.92
    - » AFFTCR 127.3
    - » AFFTCR 127.1
- Where We're Headed
  - Conduct a detailed Feasibility Study
  - Complete a more detailed Support Concept
- Plan of Action
  - Internal GSFC Guidelines document on Operational Issues
  - Actively participate in Range Community Activities

Conclusion/Summary

- Introduced the SN/TDRSS
- Discussed the Potential Use of TDRSS for Range Safety Support (TDRS-F1 already providing ELV telemetry support)
- Will continue Concept Development to Determine Feasibility of TDRSS Range Safety Support
- Will Continue to Interface with the Range Community to examine and determine Future Support

BACKUP

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SN Overview and Potential Range Safety Application

Acronyms

AFFTCR	Air Force Flight Test Center Regulation
BDA	Bermuda
CD&SC	Communications Distribution and Swtching System
CMD	command
DG	Data Group
DoD	Department of Defense
ELV	Expendible Launch Vehicle
ER	Eastern Range
ETGT	Extended TDRSS Ground Terminal
FDF	Flight Dynamics Facility
FWD	forward
GCMR	Ground Control Message
Ghz	Gigahertz
GN	Ground Network
GRO	Gamma Ray Observatory
GRTS	GRO Remote Terminal System
GSFC	Goddard Space Flight Center
HQ	headquarters
IPD	Information Processing Division
JDMTA	Jonathan Dickerson Missile Test Annex
KSA	K-Band Single Access Antenna
MA	Multiple Access
Mbps	Megabits per second
MECO	Main Engine Cut Off
Mhz	Megahertz
MIL	Merritt Island
min	minute
MOC	Mission Operations Center
ms	millisecond
NASA	National Aeronautics and Space Administration
NCC	Network Control Center
NISN	NASA Integrated Services Network (Nascom)
PMME	Performance and Measuring Monitoring Equipment
PN	Pseudo-random Noise
POCC	Payload Operations Control Center
RCC	Range Commanders Council
RF	Radio Frequency
RGRT	Remote Ground Relay Terminal
RSO	Range Safety Office
RTN	return
S/C	spacecraft
SA	Single Access
sec	second
SGLT	Space-to-Ground Link Terminal
SN	Space Network
SSA	S-Band Single Access Antenna
STGT	Second TDRSS Ground Terminal
STS	Space Transportation System

Acronyms

T&DA	Tracking and Data Acquisition
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TDS	TDRS Spare
TDZ	TDRS Zone of Exclusion
TLM	telemetry
TRK	tracking
UHF	Ultra High Frequency
USAF	United States Air Force
WPL	Wallops Island
WR	Western Range
WSC	White Sands Complex
WSGTU	White Sands Ground Terminal Upgrade
ZOE	Zone of Exclusion